



# **50 Ah Ni H2 CELL LIFE TEST RESULTS**

by

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## HISTORIC

- DEVELOPMENT OF A MEDIUM CAPACITY RANGE (30 - 50 Ah) IPV SAFT Ni H<sub>2</sub> CELL (1985 - 1988)
- SHORT TERM QUALIFICATION TESTING REALISED BY MID 1988

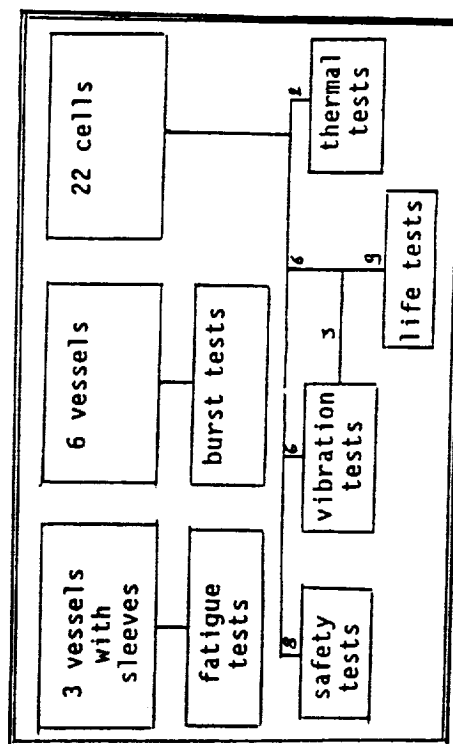
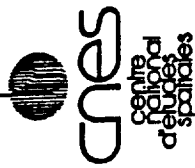


Table 1 : Qualification Test Program



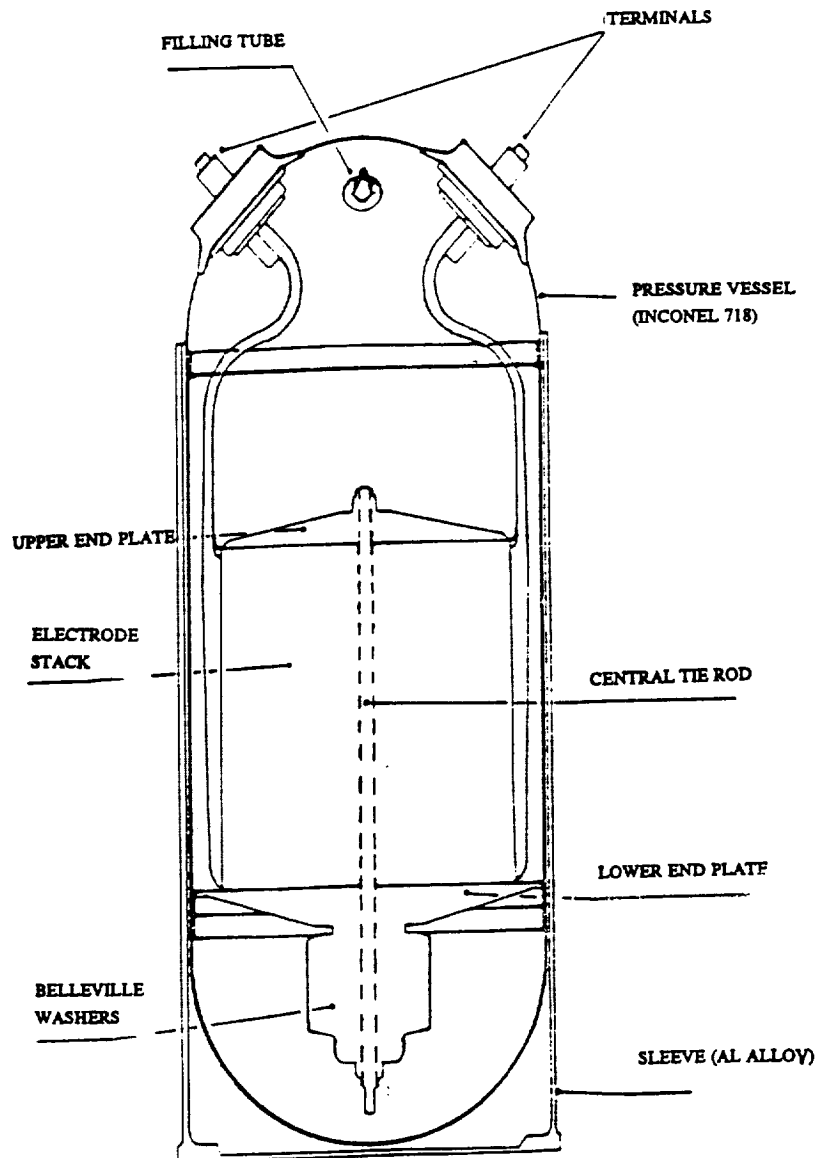
## ***SAFT 50 Ah CELL DESIGN (VHS BL SERIE)***

### **MECHANICAL/VESSEL DESIGN**

- PRESSURE VESSEL MADE OF HEAT TREATED INCONEL 718 PARTS.
- VESSEL DIAEMETER IS 3.2 INCHES AND OVERALL LENGTH IS 8 INCHES.
- WALL THICKNESS IS 0,024 INCHES.
- TERMINALS : BRAZED CERAMIC FEED THROUGH. "RABBIT EAR POSITION"
- FILLING TUBE : HARDENED INCONEL ( 1 TERMINALS PLAN)
- TIG WELDING TECHNIQUE FOR ALL JUNCTIONS.
- MOP : 1070 PSI/SAFETY FACTOR : 2,5.

# SAFT 50 Ah CELL DESIGN

(VHS BL SERIE)



1991 MSFC - Battery Workshop - 29-31/10/91

## **SAFT 50 Ah CELL DESIGN (VHS BL SERIE)**

### **ELECTROCHEMICAL/STACK DESIGN**

#### **GENERAL**

- BACK TO BACK CONFIGURATION/MONO STACK.
- CENTRAL TIE ROD/EXTERNAL. CONT. LEAD ASSEMBLY
- RIGID END PLATES/EXPANSION SYSTEM
- REDUCED STACK/WALL GAP.

#### **POSITIVE ELECTRODE**

- POROUS NICKEL SINTER (OPTIMIZED POROSITY).
- IEC ACTIVE MATERIAL (APPROPRIATE LOADING).

#### **NEGATIVE ELECTRODE**

- CURRENT COLECTOR : EXPANDED NICKEL GRID.
- CATALYST : PT CHARCOAL + TEFLONISED BINDER.
- HYDROPHOBIC BACK LAYER : MICROPOROUS PTFE.

## ***SAFT 50 Ah CELL DESIGN (VHS BL SERIE)***

### **ELECTROCHEMICAL/STACK DESIGN (suite)**

#### **SEPARATOR**

- MULTILAYERED NON WOVEN POLYAMID FELT.

#### **GAS - SCREEN**

- WOVEN NYLON MATERIAL.

#### **ELECTROLYTE**

- 31 % w KOH (BEFORE ACTIVATION)

### **THERMAL DESIGN**

#### **SINGLE PIECE SLEEVE TO BASEPLATE**

- LIGHT ALLOY.

#### **GAP INTERFILLER**

- POLYMERIC RESIN.

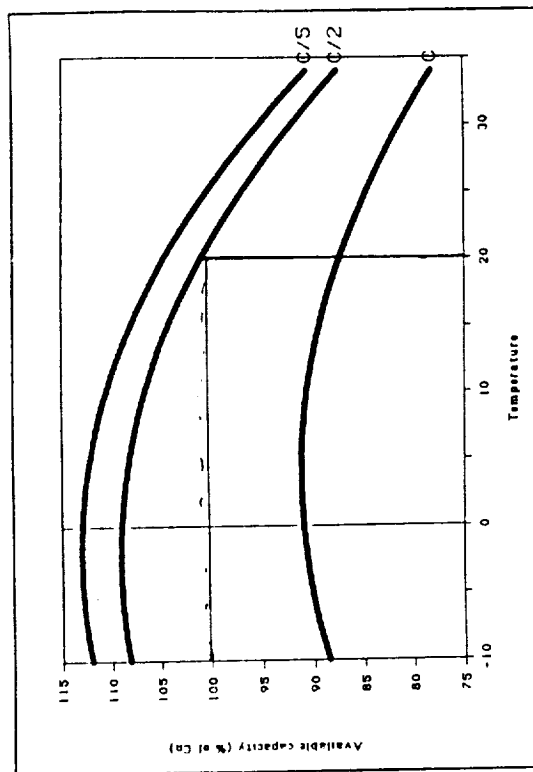


# SAFT 50 Ah CELL DESIGN (VHS BL SERIE)

## ELECTRICAL CHARACTERISTICS

CAPACITY	51,5 Ah
ENERGY DENSITY	48 Wh/Kg
VOLUMIC ENERGY	70 Wh/L
INTERNAL RESISTANCE	< 3 mΩ

MEAN VALUES ON THE QUALIFICATION LOT.



Available Capacity

## **SAFT 50 Ah CELL LIFE TEST**

### **PURPOSE**

- TO PERFORM AN ACCELERATED GEO LIFE TEST.
- TO STUDY SENSITIVITY TO MANAGEMENT PARAMETERS.
- TO ASSESS THE EFFECT OF RECONDITIONNING.

### **OBJECTIVE**

- TO EVALUATE LONG TERM ABILITY OF THE DESIGN.
- TO DEMONSTRATE AT LEAST 10 YEARS OF OPERATION.

### **SCHEDULE**

- |            |                |
|------------|----------------|
| - START UP | JULY 1988      |
| - END      | SEPTEMBER 1991 |



## ***SAFT 50 AH CELL LIFE TEST***

### **TEST CELLS AND APPARATUS**

- NINE CELLS TAKEN FROM THE QUALIFICATION BATCH (1/3 VIBRATED).
- COMPACT INDIVIDUAL SLEEVE MOUNTING ON A COLD PLATE (VERTICAL).
- THERMAL BLANKET TO LIMIT CONVECTION EXCHANGE.
- SAFETY DEVICES (TEMPERATURE CONTROLLER, HYDROGEN DETECTOR, ETC...).
- ANTI DEFLEGATING CHAMBER.

## **SAFT 50 Ah CELL LIFE TEST**

### **GEO CYCLING CONDITIONS-GENERAL**

- 45 CYCLES ECLIPSE SEASON.
- REAL TIME ECLIPSE PROFILE WITH 72 MINUTES MAXIMUM DISCHARGE TIME.
- 12 HOURS SIMULATED ECLIPSE PERIOD
- REDUCED SOLSTICE SIMULATION.
- RECONDITIONNING + STANDARD CAPACITY MEASUREMENT.

### **LIFE TEST PARAMETERS**

- |                         |               |
|-------------------------|---------------|
| - DISCHARGE REGIM       | C/1.7         |
| - DOD                   | 70 %          |
| - CHARGE REGIM          | C/14          |
| - RETURN FACTOR         | 1.15 - 1.17   |
| - REGIM                 | C/200 - C/100 |
| - REFERENCE TEMPERATURE | 10°C          |

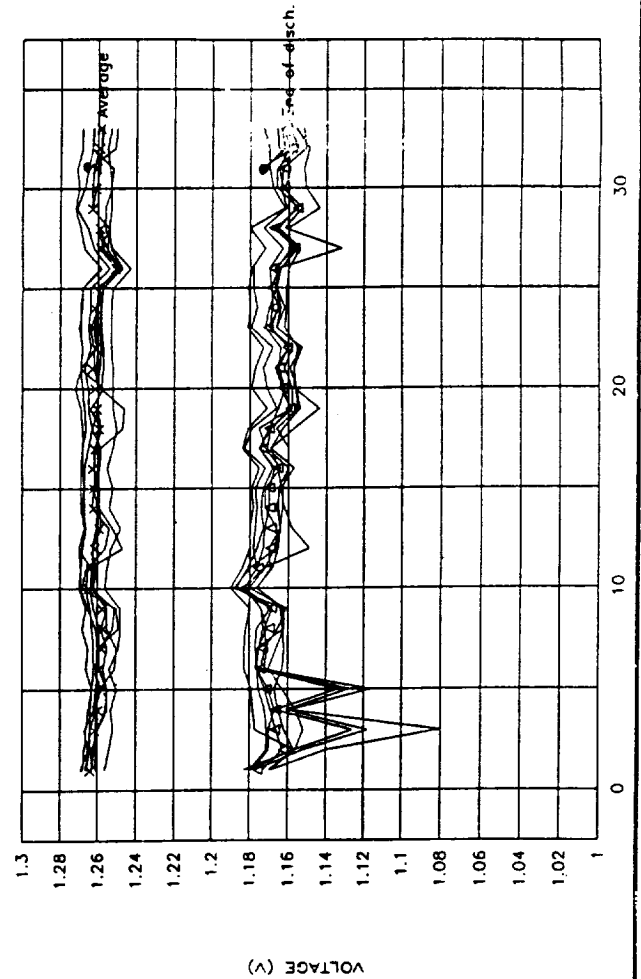
## SAFT 50 Ah CELL LIFE TEST

### RESULTS

#### DISCHARGE VOLTAGE EVOLUTION

- STABILITY FOR MEAN DISCHARGE VOLTAGE (1,26 V).

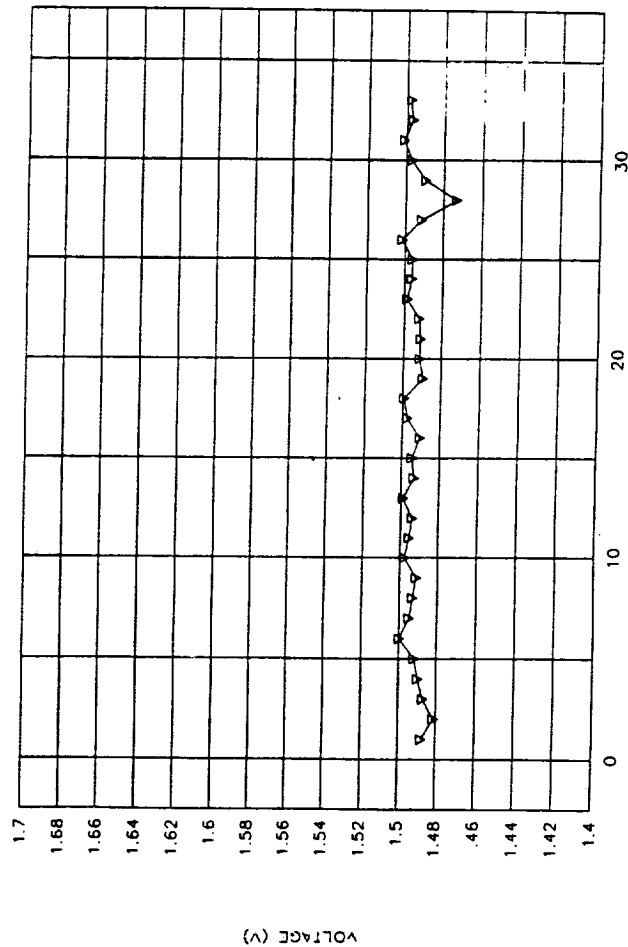
- SLIGHT DECREASE FOR EOD VOLTAGE : 1,16 V/EOL.



# SAFT 50 Ah CELL LIFE TEST RESULTS

## END OF CHARGE VOLTAGE EVOLUTION

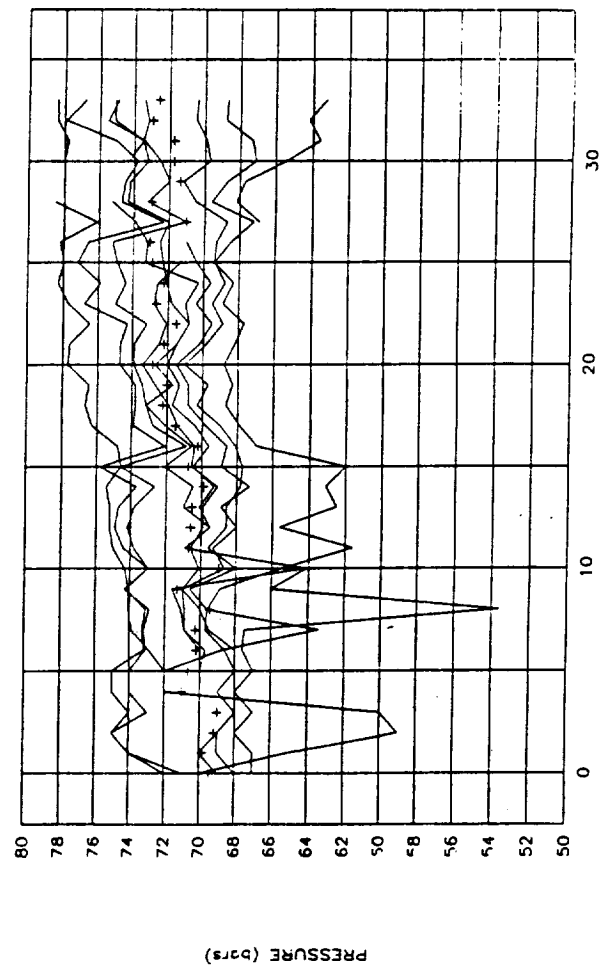
- NO APPARENT DEGRADATION (1,5 V)



## SAFT 50 Ah CELL LIFE TEST RESULTS

### END OF CHARGE PRESSURE EVOLUTION REFERENCE CYCLE

- NO PRESSURE STABILITY ALONG THE WHOLE TEST.
- AT MAXIMUM CYCLING PRESSURE  $\Delta P$  IS 4 BARS.



## **SAFT 50 Ah CELL LIFE TEST RESULTS**

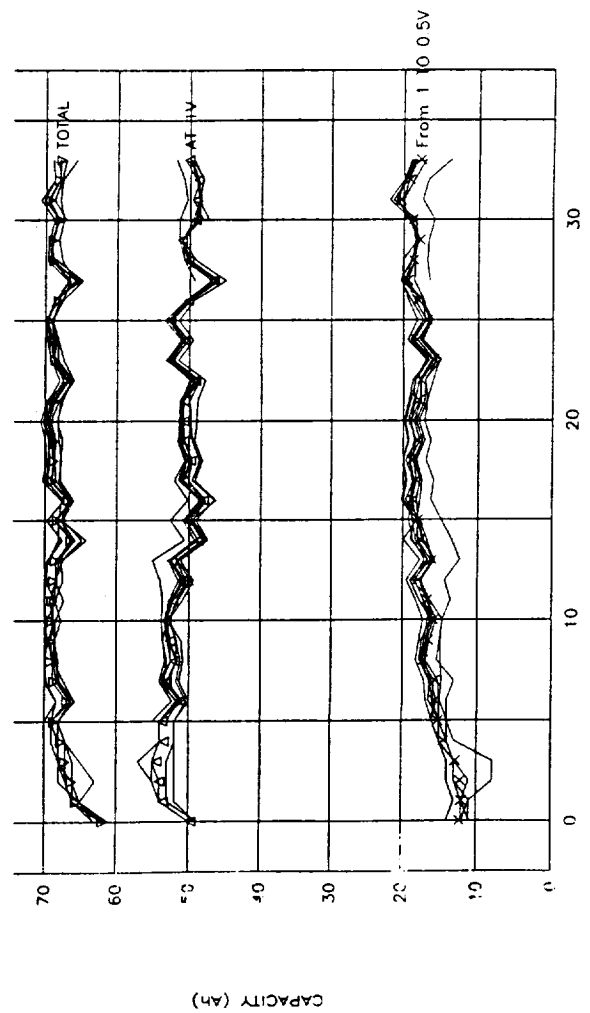
### **STANDARD CAPACITY MEASUREMENT**

- AFTER : CC ON A RESISTANCE (16 H).
- CHARGE AT C/5 WITH A CHARGE RATIO OF 1,54.
- OPEN CIRCUIT DURING 1 HOUR.
- DISCHARGE WITH TWO STEPS.
  - C/2 TO 1 V
  - C/5 TO 0,5 V
- ALL OPERATIONS AT 10°C.

## SAFT 50 Ah CELL LIFE TEST RESULTS

### STANDARD CAPACITY MEASUREMENT

- OVERALL CAPACITY REMAINS VERY STABLE.
- SLIGHT STANDARD CAPACITY FADING (54 ---> 49 Ah)
- WITH CORRESPONDING RESIDUAL INCREASE.

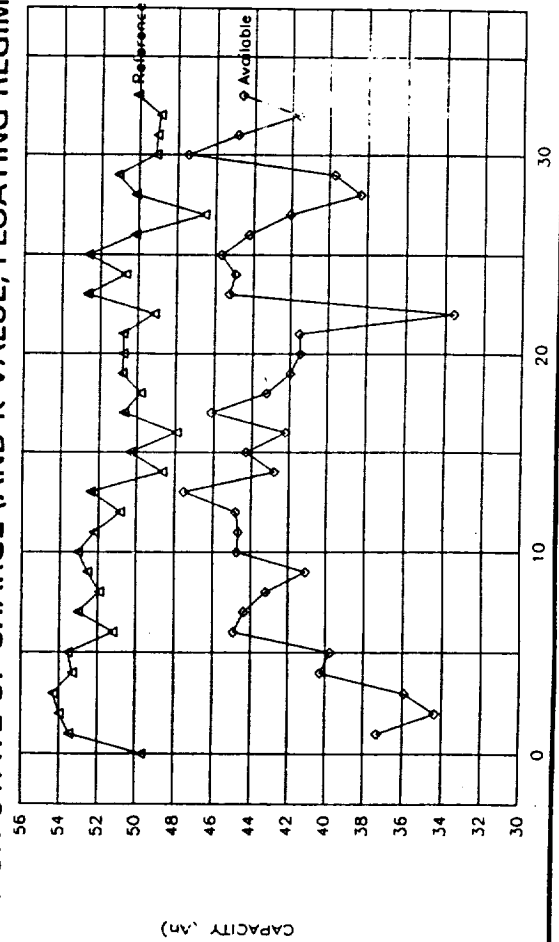


# SAFT 50 Ah CELL LIFE TEST RESULTS

## COMPARISON BETWEEN ON CYCLE AVAILABLE CAPACITY

### AND STANDARD CAPACITY

- CAPACITY AT 1 V UNDER CYCLING DISCHARGE REGIM REPRESENTS 80 TO 95 % (WRT STANDARD CAPACITY).
- DEPENDS ON STATE OF CHARGE (AND K VALUE, FLOATING REGIM, TEMPERATURE).

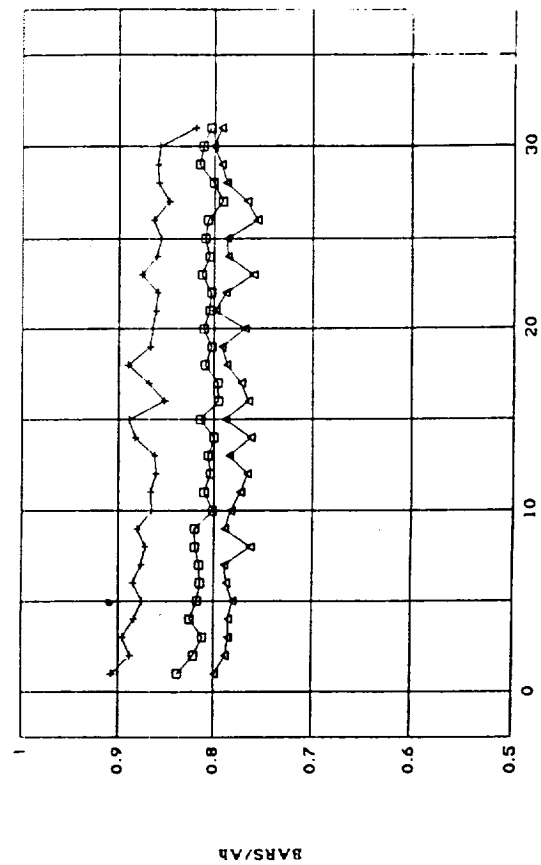




# **SAFT 50 Ah CELL LIFE TEST RESULTS**

## **COULOMBIC EFFICIENCY EVOLUTION FOR REFERENCE CYCLE**

- SMALL DISCHARGE EFFICIENCY DIMINUTION/TO COUPLE WITH MAX PRESSURE EVOLUTION.



## ***SAFT 50 Ah CELL LIFE TEST RESULTS***

### **CONSTANT POWER DISCHARGE EFFECT AND TRICKLE CHARGE EFFECT**

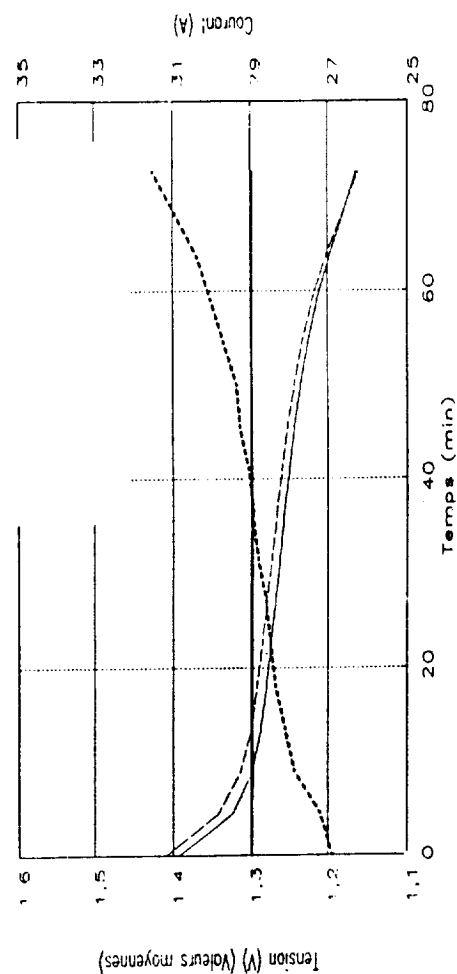
- ON SEASONS 29 TO 31 CELLS WERE SPLITTED ON 3 GROUPS.
  - . STD CYCLING (FOLLOW ON) 3 CELLS.
  - . CONSTANT POWER DISCHARGE 3 CELLS
  - . TRICKLE CHARGE : CONTINUOUS C/90 FOR TWO MONTHS 2 CELLS
- ONE CELL OUT OF SERVICE (SHORT CIRCUIT) DUE TO TEST ERROR AND INSULATION FAILURE.

## SAFT 50 Ah CELL LIFE TEST RESULTS

### COMPARISON BETWEEN CONSTANT CURRENT AND CONSTANT POWER DISCHARGE

#### SEASON 31. CYCLE 23.

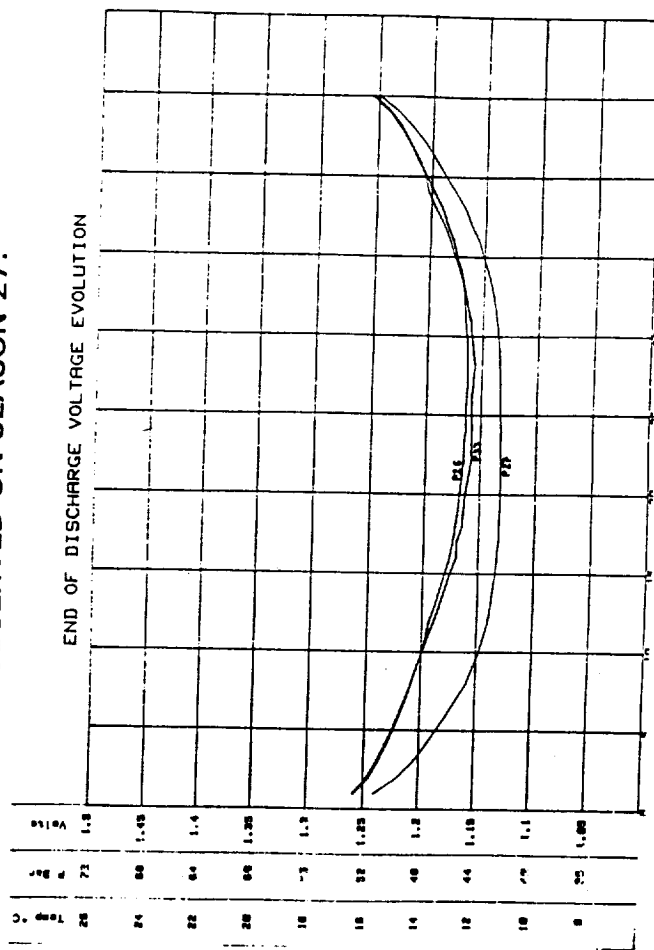
- DISCHARGE VOLTAGE AT P ct IS HIGHER THAN AT I ct.
- EOD VOLTAGES ARE IDENTICAL.
- CURRENT IS 10 % HIGHER (WRT I CT) AT END OF DISCHARGE.



# SAFT 50 Ah CELL LIFE TEST RESULTS

## RECONDITIONNING EFFECT

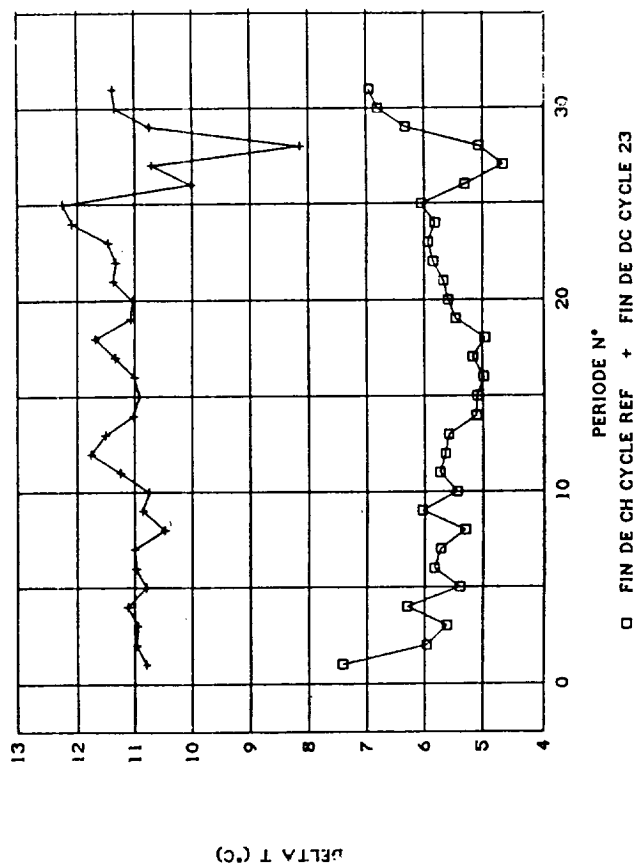
- CELL 9 WASN'T RECONDITIONED AFTER SEASON 26.
- DIRECT EFFECT IS OBSERVED ON SEASON 27.



# SAFT 50 Ah CELL LIFE TEST RESULTS

## TEMPERATURE EVOLUTION

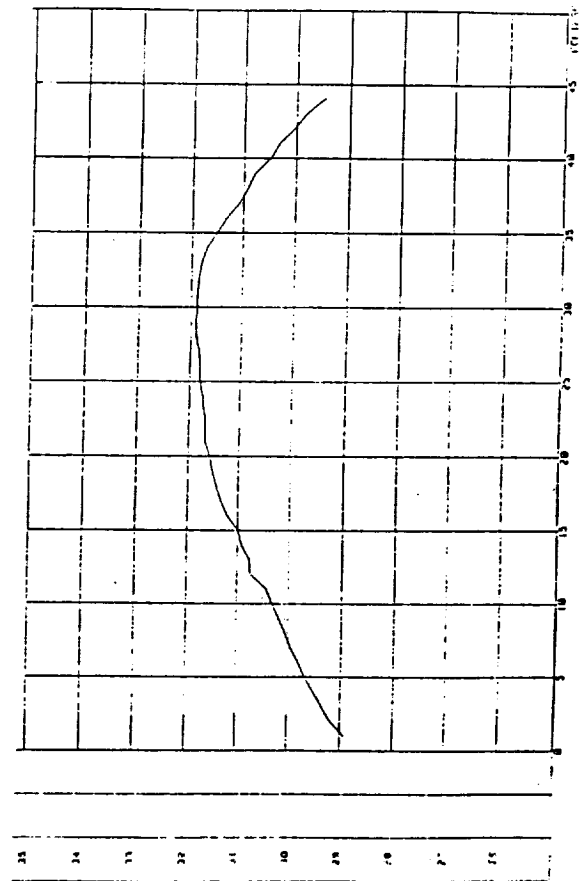
- CONDUCTION GRADIENT BETWEEN CELL/SLEEVE WALL AND BASEPLATE ARE SLIGHTLY RISING AS AN AGEING EFFECT WITH CYCLES.



# SAFT 50 Ah CELL LIFE TEST RESULTS

## EOD CURRENT PROFILE (POWER ct) SEASON 29

- ASYMMETRIC CURVE WITH MAXIMUM AT CYCLE 30.



## ***SAFT 50 Ah CELL LIFE TEST RESULTS***

### **TRICKLE CHARGE EFFECT**

- CONTINUOUS CHARGE AT C/90 ENHANCE STATE OF CHARGE.
- AS DIRECT RESULT ON CYCLE DISCHARGE CAPACITY IS IMPROVED (50 Ah VERSUS 47 Ah) BUT STD CAPACITY ISN'T AFFECTED.
- DISCHARGE VOLTAGES ON SEASON 31 (AFTER TWO MONTHS OF TRICKLE) ARE 10 mV HIGHER/CELLS WITHOUT TRICKLE.

## ***SAFT 50 Ah CELL TEST RESULTS***

### **SUMMARY**

- 33 ECLIPSE SEASONS COMPLETED AND MORE THAN 3 YEARS OF CYCLING REALISED.
- RECONDITIONNING IS MANDATORY TO INSURE SATISFACTORY EOD VOLTAGES.
- AVERAGE EOD VOLTAGES NEVER SLOW DOWN 1,16 V/CELL.
- REAL DOD NEVER EXCESS 73 % / CAPACITY FADING ENCOUNTERED.
- NO ELECTRICAL LIMITATIONS WITH CONSTANT POWER DISCHARGE.

### **ADDITIVES**

- DPA RUN ON FAILED CELL.
- EXTENSIVE CHARACTERIZATION PROGRAMM IS SET UP AND WILL BE RUN SOON.

### **IMPLEMENTED DATA**

- AN OTHER LIFE TEST HELD AT AEROSPATIALE (20 SEASONS PLANNED).

nine 50 Ah SAFT CELLS.

70 % DoD ; 10°C ; REAL TIME ECLIPSE ; K = 1,12 ;

AFTER 9 SEASONS RESULTS ARE VERY SIMILAR.





## ***SAFT 50 Ah CELL LIFE TEST***

### **CONCLUSIONS**

***EXPECTED GOAL (10 YEARS) LARGELY COMPLETED IN EXCESS.***

- VHS BL SERIE EXHIBIT A GOOD BEHAVIOUR.
- THIS TECHNOLOGY AUTHORIZED MORE THAN 15 YEARS AT 70 % DoD AND 10°C ON ACCELERATED TESTING.

***NEXT STEP WILL CONSIST ON A LIFE TEST TO PERFORM ON 20 VHS 90 CM SAFT CELLS.***

- LIFE TEST AT BTC/ESA/ESTEC.
- START UP : BEGINNING OF 1992.
- FIVE YEARS LIFE TEST.

